

The Female Athlete: The Role of Gender in the Assessment and Management of Sport-Related Concussion

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KEYWORDS

- Concussion • Gender differences • Females • Symptoms

Recent estimates from the Centers for Disease Control and Prevention indicate that sport and recreational traumatic brain injuries (TBIs) have increased from 300,000 per year¹ to approximately 1.6 million to 3 million per year in the United States.² This trend suggests that concussions are a growing problem that affects athletes at both the high school and collegiate level. An increase in female participation in sport shows that there are currently more than 178,000 women participating on National Collegiate Athletic Association (NCAA) teams³ and approximately 3 million women playing organized high school sports.⁴ These trends have provided an impetus for researchers to examine differences between the genders, which might affect the assessment and management of sport-related concussion. Therefore, this article addresses the role of gender in the assessment and management of sport-related concussion.

GENDER DIFFERENCES IN THE EPIDEMIOLOGY OF SPORT-RELATED CONCUSSIONS

Several researchers have identified differences in the incidence of sport-related concussion among collegiate athletes of different genders. Covassin and colleagues⁵ examined NCAA injury data from 1997 to 2000 and found collegiate female athletes to

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be at a higher risk of concussions occurring in games than collegiate male athletes. Specifically, women's soccer (2.09/1000 athlete exposure [AE]) and basketball (0.74/1000AE) had a higher injury rate than men's soccer (1.36/1000AE) and basketball (0.48/1000AE).⁵ Hootman and colleagues⁶ recently summarized 16 years (1988–2004) of NCAA injury data and reported concussions accounted for a higher injury rate in women's ice hockey (0.91/1000AE), soccer (0.41/1000AE), and basketball (0.22/1000AE) than men's ice hockey (0.41/1000AE), soccer (0.28/1000AE), and basketball (0.16/1000AE). Women's ice hockey may be misleading because data were collected only for 3 years (2000–2003) for this sport versus 16 years for the other sports.⁶ According to these data, it appears that female collegiate athletes are at a higher risk for concussion than male collegiate athletes.

There are only a few studies published that have examined gender differences on incidence rates for sport-related concussion in high school athletes. One of the first studies to examine concussion at the high school level was conducted in the 1990s by Powell and Barber-Foss.⁷ Similar to the epidemiologic trends observed at the collegiate level, in high school sports played by both sexes, girls had a slightly higher game injury rate than boys. Specifically, girl's soccer (0.71/1000AE), basketball (0.42/1000AE), and softball (0.13/1000AE) had a higher game injury rate for concussions than boy's soccer (0.57/1000AE), basketball (0.28/1000AE), and baseball (0.12/1000AE). A more recent investigation by Gessel and colleagues⁸ reported that concussions accounted for a higher game injury rate in high school girls' sports (soccer, 0.97/1000AE; basketball, 0.60/1000AE) than in high school boys' sports (soccer, 0.59/1000AE; basketball, 0.11/1000AE). It appears that the incidence rates of concussion differ by gender at both the collegiate and high school levels.

Numerous explanations have been proposed to account for female athletes being more at risk for concussion than male athletes. Studies have found that women have a decreased head-neck segment mass compared with male athletes, which could result in greater angular acceleration to the head after a concussive impact.^{9–13} College-age women have been found to have approximately 43% less head-neck segment mass compared with college-age men.¹⁰ Researchers have also suggested that female soccer players have a larger ball-to-head size ratio than men, possibly predisposing them to concussion.^{13,14} Moreover, female athletes have decreased neck strength and neck girth compared with male athletes.^{10,11,15} Tierney and colleagues¹⁰ reported that female collegiate students showed 49% less neck strength and 30% less neck girth compared with male collegiate students. Similarly, Garces and colleagues¹⁵ reported that male collegiate students had 30% to 40% more strength in cervical extensors and flexors than female collegiate students. Mansell and colleagues¹⁶ investigated an 8-week cervical resistance training program on neck girth, cervical strength, and head-neck segment dynamic stabilization in collegiate soccer players. Although the neck girth and strength were increased in female soccer players, there were no gender-related differences in head-neck segment dynamic stabilization during a force application (ie, weight) in collegiate soccer players.

It is currently debated whether estrogen, the primary female sex hormone, has a detrimental or a neuroprotective effect with regard to concussion. Animal models have shown that estrogen treatment before experimentally induced brain injury (eg, fluid percussion brain injury) has protective effects for male rats but detrimental effects for female rats.¹⁷ One reason may be that estrogen acts as a neuroprotector because of the hormone's lipid antioxidant properties.¹⁸ There is limited research published on the role that estrogen may have on the risk of concussion.

Studies have also found that female athletes tend to report more concussion symptoms than male athletes.¹⁹ This disparity in self-reporting of concussion symptoms

could be because of the nature of the male sport environment, especially in contact and collision sports (eg, football, wrestling, hockey) in which the incidence of concussion is highest. Male athletes are under constant pressure to play through pain, to show their masculinity and their toughness. They are oftentimes praised for their courage and rewarded when playing through pain and injury. In contrast, studies have found that female athletes are more concerned about their future health than male athletes.²⁰ These interesting differences between the male and female sport environments may explain the observed differences in the self-reporting of concussion symptoms between genders.

DIFFERENCES IN SPORT-RELATED CONCUSSION OUTCOMES BETWEEN GENDERS

Gender differences in cognitive function have been well documented. Specifically, women perform better on tasks involving verbal memory and perceptual motor speed, whereas men perform better on tasks of visuospatial ability.²¹ These differences have also been documented by neurocognitive measures commonly used for managing concussion.²²⁻²⁴ Covassin and colleagues²⁴ reported that at the college level, women performed higher on verbal memory than men, whereas men showed higher visual memory scores than women. These results warrant consideration of differences between genders in cognitive performance after concussion.

Several researchers have suggested that female athletes present more concussion symptoms acutely and take a longer period to recover from concussions^{19,25,26} than male athletes.¹⁹ Broshek and colleagues¹⁹ found that, in high school and college athletes, concussed women displayed slower reaction times and greater total symptoms than concussed males. When excluding sports that require the use of a helmet (football), women were twice as likely as men to exhibit cognitive impairments.¹⁹ These findings were among the first to suggest that sport-related concussion may affect athletes differently based on gender. However, athletes in this study represent significantly fewer women (28%) than men (72%), which may limit the generalizability of these findings. Nonetheless, more recent studies have also highlighted gender differences in sport-related concussion outcomes.

Covassin and colleagues²⁶ found gender differences in neurocognitive performance in concussed collegiate athletes. Specifically, female concussed athletes showed significantly lower scores on visual memory than male concussed athletes. In a more recent study, Colvin and colleagues²⁵ found that concussed collegiate female soccer players showed significantly slower reaction times and higher total symptom scores than concussed male soccer players.

Differences based on gender have also been found in the reporting of postconcussion symptoms. Female athletes tend to have a greater number of and more prolonged symptoms than male athletes.^{19,27,28} Preiss-Farzanegan and colleagues²⁸ reported that women who incurred a sport-related mild TBI reported increased symptoms, particularly with regard to headache, dizziness, fatigue, and poor concentration, when compared with men. In a meta-analysis by Farace and Alves,²⁷ women who incurred a TBI had a worse outcome on 85% of measured variables, primarily symptoms, including headache, dizziness, anxiety, fatigue, and poor memory and concentration, than men.

Differences in the reporting of postconcussion symptoms between concussed male and female athletes have been attributed to neuroanatomical factors, organizational (cerebral) variability, hormonal discrepancies, and sports environment/social differences.¹⁹ de Courten-Myers²⁹ reported that men had a greater number of cortical neuronal densities, whereas women had a greater area of neuropil (ie, containing

unmyelinated neuronal processes). Esposito and colleagues³⁰ found that women have a greater cerebral blood flow rate coupled with a higher basal rate of glucose metabolism. These 2 differences could yield a more exacerbated neurometabolic cascade (ionic fluxes followed by hypoglycolysis) after concussion.³¹ In addition, the decrease in cerebral blood flow and increase in metabolic demands caused by brain injury may interact with the already increased metabolic demands in women.¹⁹

There has long been a debate in the literature as to whether estrogen has a detrimental or a protective effect on concussion outcome. If estrogen has a deleterious effect, it may be because of receptor-mediated alterations in energy metabolism¹⁷ or estrogen-potentiating neuronal response to excitatory amino acid.³² Emerson and colleagues¹⁷ found that estrogen improves neurologic outcome after a TBI in male rats but shows detrimental effects in female rats. In contrast, Kupina and colleagues³³ found that estrogen had a neuroprotective effect because female mice demonstrated a better outcome than male mice after experimental brain injury. Specifically, male mice had a 20% mortality rate, whereas no deaths were recorded among female mice. Most research exploring the protective or deleterious effects that hormones may have on brain injury outcome has been conducted using animal models. Continued research in this area in humans is warranted.

CONSIDERING GENDER DIFFERENCES IN THE ASSESSMENT AND MANAGEMENT OF SPORT-RELATED CONCUSSION

The assessment and management of sport-related concussion has seen vast improvement over the past decade. Results from empirical studies have increased the knowledge and awareness of sport-related concussion. As a result, management strategies for this injury have been refined, benefiting both sports-medicine professionals and injured athletes. More specifically, this progress has seen the suggested abolishment of historically used concussion grading scales, improved diagnostic methods, individual case management recommendations, and the use of computerized neurocognitive test batteries.^{34,35}

The management of sport-related concussion continues to be a germane issue for clinicians and researchers alike. Until recently, determining the status of a concussed athlete was primarily a subjective decision made by sports medicine professionals. It is now recommended that the assessment and management of sport-related concussion take on a multifaceted approach that consists of various measures that may include a sideline mental status examination, a postural stability assessment, and a neurocognitive test battery.³⁶ These measures, used in conjunction with symptom inventories, offer clinicians a wide variety of information on the status of recovery of the concussed athlete. When implemented with the recommended pre- and posttest methodology, these measures add objectivity to concussion assessment and management.³⁷

Gender differences in the risk, symptoms, and recovery should be considered when assessing and managing a concussed athlete. The incidence of sport-related concussion in high school and collegiate populations may be higher for female athletes in basketball, ice hockey, and soccer.^{5,6} Therefore, health care professionals, coaches, athletes, and parents need to pay close attention to female athletes who incur a direct or indirect blow to the head, especially in the aforementioned sports. Moreover, sports medicine professionals need to pursue concussion evaluation with the same due diligence for female athletes as for male athletes.

Disparities in the reporting of concussion symptoms between male and female athletes should be a consideration when managing a concussion. Female concussed

athletes report more symptoms of dizziness, fatigue, concentration, and lightheadedness than male concussed athletes.^{19,28} Female soccer players who report headache symptoms 1 week postconcussion have greater cognitive impairments than athletes who do not report headache symptoms. In the general population, women have a higher incidence of headaches than men.³⁸ Moreover, women have almost double the prevalence of migraine headaches compared with men.^{25,39-41} Recently, researchers have found that concussed athletes who display migraine headache symptoms take longer periods to recovery postinjury.^{42,43} This predilection toward migraines may translate to a longer recovery time for female athletes.

Preliminary studies suggest that female athletes take longer periods to recover from a concussion than male athletes,^{19,25,26} including on measures of reaction time²⁵ and visual memory.²⁶ More specifically, female concussed athletes may take up to 7 days longer to recover from a concussion than male concussed athletes. As a result of these preliminary studies, clinicians should be aware of varying recovery time from concussion between male and female athletes.

SUMMARY

The detection and management of concussion in sport continue to be an important issue for sports medicine professionals. Advancements in the knowledge of this injury continue to reshape concussion management to ensure the well-being and safety of athletes. Recent studies suggest that the risk and recovery from sport-related concussion may vary between male and female athletes, with women having a higher risk of sustaining a concussion and taking a longer time to recover than men. Therefore, sports medicine professionals should not assume that the recovery from concussion is uniform in both male and female athletes. However, more research is warranted on concussed female athletes, particularly studies examining mechanism, symptoms, and recovery time.

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